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3. Full name, address and postcode of the or of each applicant *(underline all surnames)* — Phoqus Pharmaceuticals Limited, 10 Kings Hill Avenue, Kings Hill, West Malling, Kent ME19 4PQ

   Patents ADP number *(if you know it)* — 8655375001

   If the applicant is a corporate body, give the country/state of its incorporation — United Kingdom

4. Title of the invention — Method and apparatus for the application of powder material to substrates

5. Name of your agent *(if you have one)* — Abel & Imray

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Method and Apparatus for the application of powder material to substrates

The present invention relates to a method and apparatus for the application of powder material to substrates. The invention relates more particularly, but not exclusively, to the electrostatic application of powder material to solid dosage forms.

A "solid dosage form" can be formed from any solid material that can be apportioned into individual units and is, therefore, a unit dose form. A solid dosage form may be, but is not necessarily, an oral dosage form. Examples of pharmaceutical solid dosage forms include pharmaceutical tablets and other pharmaceutical products that are to be taken orally, including pellets, capsules and spherules, and pharmaceutical pessaries, pharmaceutical bougies and pharmaceutical suppositories. Pharmaceutical solid dosage forms can be formed from pharmaceutical substrates that are divided into unit dose forms. Examples of non-pharmaceutical solid dosage forms include items of confectionery, washing detergent tablets, repellents, herbicides, pesticides and fertilisers.

The electrostatic application of powder material to solid dosage forms is known. Examples of patent specifications describing such applications are WO 96/35516 and WO 02/49771.

When coating solid dosage forms electrostatically with powder it is desirable to position each solid dosage form appropriately in relation to the powder applicator and that requires individual handling of each solid dosage form. Also, if powder is to be applied to opposite faces of the solid dosage form while it is held in a desired position it becomes desirable to be able to turn over the solid dosage form during the handling of it. On a laboratory scale, such handling of the solid dosage forms presents little problem, but if it is desired to apply powder to solid dosage forms at a reasonably high rate, as required for industrial production, the handling of the solid dosage forms becomes a problem.

In WO 96/35516 solid dosage forms are held on a first rotary drum for coating a face of the solid dosage form and are then transferred onto a second rotary drum for coating an opposite face. Such a method has proved workable but there are losses in production, especially in connection with the loading and unloading of solid dosage forms onto and from the drums, and the transfer of solid dosage forms from one drum to another. There is also a limit to the path length (the circumference of the drum) available for treatment of a face of the solid dosage form and the system is not particularly flexible and cannot therefore easily be adapted from a set up for treating one solid dosage form according to one set of requirements to a set up for treating another solid dosage form according to another set of requirements.

In the applicant's co-pending application no GB 0314188.4, this problem is solved by using platens to convey the substrates. The substrates are placed onto each platen, the platens are conveyed around a path and the substrates are electrostatically coated with powder material. The platen may then be inverted and the substrates transferred to a second platen, on which the substrates are coated on their other side with powder material. The platen is then removed from the path and the substrates are removed from the platen. Whilst this method has proved to be very successful, since each substrate is maintained in the platen and is not individually handled, there are nonetheless problems associated with this method. There are losses in production in connection with the loading and unloading of the platens onto and from the path. In addition, as the platens are separable from the path, great care must be taken that the platen dimensions and registration onto the path is correct so that the distance between the substrates and the source of powder material in the developer may be accurately controlled.

It is an object of the invention to provide an improved method and apparatus for the application of powder material to substrates.

According to a first aspect of the invention there is provided an apparatus for electrostatically applying a powder material to substrates, the apparatus comprising:

a plurality of platens fixed to move along an endless path, each platen being arranged to hold a plurality of substrates;

driving means for driving the platens along the endless path; and

an applicator assembly for applying the powder material to the substrates, the applicator assembly being located on a part of the endless path.

By fixing the platens to move along the endless path, the distance between the substrates and the source of powder material in the developer may be more accurately controlled.

In one embodiment, the applicator assembly comprises at least one applicator having a supply of powder material and charging means for electrostatically charging the powder material.

Preferably, a portion of the applicator is replaceable by a user, the replaceable portion including the supply of powder material.

Advantageously, the apparatus further includes a fusing assembly for fusing powder material electrostatically applied to the substrates, the fusing assembly being located on a part of the endless path. In one embodiment, the fusing assembly comprises a plurality of fusing devices disposed in series along the endless path.

The fusing may be carried out with infra-red radiation, characterised in that the wavelength of the radiation used corresponds to a significant peak present in the infra-red spectrum of the powder material but not present to any significant extent in the infra-red spectrum of the substrate.

In one embodiment, fusing is carried out with infra-red radiation of wavelength in the range of from 3-6μm.

Preferably, the apparatus further includes a loading station for loading substrates onto the platens. Preferably, the apparatus further includes an unloading station for removing substrates from the platens.

In one embodiment, the apparatus further includes a transfer station for transferring the substrates between platens. This is useful when both sides of the substrates need to be coated with powder material. The first side may be coated in a first platen, then the substrates may be transferred to a second platen and the second side of the substrates may be coated in the second platen.

Preferably, the apparatus further includes at least one detector for inspecting the platens. The detector may be arranged to detect when a substrate is missing from a given position on a platen or to detect when a substrate is present at a given position on a platen. The at least one detector may comprise a plurality of optic fibres. The at least one detector may be arranged to detect a variety of colours. Preferably the at least one detector is remotely operable. The detector may be arranged to provide a signal to a user.

In one embodiment, the driving means is arranged to drive the platens along the endless path at a plurality of speeds. By allowing each platen to move at a different speed from its neighbouring platen, while on the same endless path, the efficiency of the coating process is greatly improved.

In a preferred embodiment, the endless path is substantially horizontal.

In the case where the endless path is horizontal, the apparatus preferably includes a vertical partition separating the driving means from the platens, the

driving means being located in a non-product region and the platens being located in a product region. The apparatus may further include a second vertical partition separating the non-product region from the product region, the first and second vertical partitions defining a substantially annular chamber between the non-product region and the product region. The substantially annular chamber may include an air flow in the vertical direction.

Separating the product region and non-product region is advantageous in two respects. Firstly, the substrates are less likely to become contaminated as they are separated from the mechanics of the system. This is particularly important in a pharmaceutical context. Secondly, the drive means is less likely to become dirty with excess powder material and this reduces costs of replacement and repairs.

Advantageously, the platens are fixed to move along the endless path in pairs, one of the platens in the pair being located above the other platen in the pair. In that case, the platens in each pair may be movable with respect to one another in the vertical direction. Preferably, the platens are rotatably mounted. In one embodiment, the upper platen is located directly above the lower platen and the platens are fixed in the horizontal direction although are free to move in the vertical direction.

In the case where the platens are fixed to move along the endless path in pairs, the applicator assembly for applying the powder material to the substrates comprises at least one upper applicator for applying the powder material to substrates in the upper platen and at least one lower applicator for applying the powder material to substrates in the lower platen.

The upper and lower applicators may be arranged to supply powder material to the substrates substantially simultaneously. Alternatively, the upper and lower

applicators may be arranged to supply powder material to the substrates sequentially.

In the case where the platens are fixed to move along the endless path in pairs, the apparatus may further include a fusing assembly comprising an upper fuser for fusing powder material electrostatically applied to the substrates in the lower platen and a lower fuser for fusing powder material electrostatically applied to the substrates in the upper platen.

Advantageously, the upper and lower fusers are arranged to fuse powder material on the substrates substantially simultaneously. This is particularly advantageous as the fusing step is often the limiting time factor on the process. Therefore, if the powder material on substrates in two platens can be fused simultaneously, this will improve the efficiency of the coating process.

In the case where the platens are fixed move along the endless path in pairs, the apparatus may further include a transfer station for transferring substrates from the upper platen to the lower platen.

The transfer station may be arranged to move the platens relative to one another in the vertical direction such that a face of the lower platen is adjacent a face of the upper platen, the face of the upper platen holding a plurality of substrates, to shift the plurality of substrates from the face of the upper platen to the adjacent face of the lower platen and to separate the adjacent faces of the upper and lower platens.

Preferably, the transfer station includes at least one vibrator for vibrating one or both platens. Vibrating one or both platens ensures that all the substrates are successfully transferred between the platens.

According to the first aspect of the invention, there is also provided a method for electrostatically applying a powder material to substrates, the method comprising the steps of:

providing a plurality of platens fixed to move along an endless path, each platen being arranged to hold a plurality of substrates;

placing the substrates on the platens;

driving the platens in series along an endless path; and

electrostatically applying a powder material to the substrates on the platens.

In one embodiment, the step of electrostatically applying a powder material comprises driving the platens past at least one applicator having a supply of powder and charging means for electrostatically charging the powder material.

Preferably, the method further comprises the step of fusing the powder material after it is electrostatically applied. In one embodiment, the step of fusing comprises driving the platens past a plurality of fusing devices disposed in series along the endless path.

Preferably, the method further comprises the step of removing the substrates from the platens after the powder material has been electrostatically applied.

Preferably, the method further comprises the step of transferring the substrates between platens. The step of transferring the substrates between platens may comprise vibrating one or both platens.

In a preferred embodiment, the method further comprises the step of inspecting the substrates in the platens. The step of inspecting the substrates in the platens is preferably carried out by at least one detector for inspecting the platens. The at least one detector may comprise a plurality of optic fibres. The at least one detector may be arranged to detect a variety of colours. Preferably the at least

one detector is remotely operable. The detector may be arranged to provide a signal to a user.

In one embodiment, the step of driving the platens along the endless path comprises driving the platens simultaneously at a plurality of speeds.

The endless path along which the platens are driven is preferably substantially horizontal.

The substrates may be pharmaceutical substrates. The substrates may be solid dosage forms. The substrates may be cores of pharmaceutical tablets.

According to the first aspect of the invention, there is also provided an apparatus as previously described for carrying out the method previously described.

According to a second aspect of the invention, there is provided a method of electrostatically applying a powder material to opposite faces of each of a plurality of substrates, the method comprising the steps of:

providing an upper platen and a lower platen, the upper platen being located vertically above the lower platen, each platen being arranged to hold a plurality of substrates;

providing a plurality of substrates on the upper face of the upper platen;

electrostatically applying powder material to exposed first faces of each of the plurality of substrates on the upper platen;

rotating the upper platen so that the plurality of substrates is located on the lower face of the upper platen;

moving the platens relative to one another in the vertical direction such that the upper face of the lower platen is adjacent the lower face of the upper platen;

shifting the plurality of substrates from the lower face of the upper platen to the upper face of the lower platen;

separating the adjacent faces of the upper and lower platens; and

electrostatically applying powder material to exposed second faces of each of the plurality of substrates on the lower platen.

Preferably, the step of shifting the plurality of substrates from the lower face of the upper platen to the upper face of the lower platen includes vibrating one or both platens.

According to the second aspect of the invention, there is also provided an apparatus for electrostatically applying a powder material to substrates, the apparatus comprising:

a plurality of pairs of platens fixed for movement about an endless horizontal path, each pair of platens comprising a lower platen and an upper platen located vertically above the lower platen, each platen being arranged to hold a plurality of substrates;

an applicator assembly for applying the powder material to the substrates, the applicator assembly being located on a part of the endless path; and

a transfer station for moving the platens relative to one another in the vertical direction such that the upper face of the lower platen is adjacent the lower face of the upper platen, the lower face of the upper platen holding a plurality of substrates, for shifting the plurality of substrates from the lower face of the upper platen to the upper face of the lower platen and for separating the adjacent faces of the upper and lower platens.

The transfer station preferably comprises a vibrator for vibrating the upper and/or lower platens.

Preferably, the applicator assembly comprises at least one upper applicator for applying the powder material to substrates in the upper platen and at least one lower applicator for applying the powder material to substrates in the lower platen.

According to a third aspect of the invention, there is provided an apparatus for electrostatically applying a powder material to substrates, the apparatus comprising:

a plurality of platens fixed to move along an endless path, each platen being arranged to hold a plurality of substrates;

an applicator assembly located on a part of the endless path for applying the powder material to substrates; and

driving means for driving the platens along the endless path, the driving means being arranged to drive platens simultaneously at a variety of speeds.

According to the third aspect of the invention, there is also provided a method for electrostatically applying a powder material to substrates, the method comprising the steps of:

providing a plurality of platens fixed to move along an endless path, each platen being arranged to hold a plurality of substrates;

placing the substrates on the platens;

driving the platens in series along an endless path, each platen being independently driveable at a variety of speeds; and

electrostatically applying the powder material to the substrates on the platens.

According to a fourth aspect of the invention, there is provided a carriage for conveying substrates along a path, the carriage comprising:

an upper platen for holding a plurality of substrates;

a lower platen for holding a plurality of substrates;

a bracket for supporting the upper and lower platen, the upper and lower platen being rotatably mounted on the bracket and being movable vertically with respect to one another; and

driving means for driving the carriage along the path.

In one embodiment, when the substrates are conveyed along the path by the carriage, the vertical separation of the upper platen and the lower platen is substantially preselected by a user, but the upper platen and/or the lower platen are free to move a small amount in the vertical direction. Allowing the upper and/or lower platens to move a small amount in the vertical direction allows the distance between an applicator for applying powder material to the substrates and the substrates themselves to be easily controlled and adjusted.

According to a fifth aspect of the invention, there is provided an apparatus for electrostatically applying a powder material to substrates, the apparatus comprising:

a product region comprising a plurality of platens fixed to move along an endless path, each platen being arranged to hold a plurality of substrates and an applicator assembly located on a part of the endless path for applying the powder material to substrates;

a non-product region comprising driving means for driving the platens along the endless path; and

a partition separating the product region and the non-product region.

Preferably, the apparatus further comprises a second partition separating the product region and the non-product region, the two partitions defining an insulating chamber.

The insulating chamber may include an air flow in a direction substantially parallel to the partitions. The airflow acts to remove any particles which have inadvertently entered the annular chamber through one of the partitions. This provides a high level of isolation of the product and non-product regions.

In one embodiment, the endless path is substantially horizontal and the partition or partitions is/are substantially vertical.

According to a sixth aspect of the invention, there is provided a method for fusing a powder coating on a substrate, in which fusing is carried out with infra-red radiation, characterised in that the wavelength of the radiation used corresponds to a significant peak present in the infra-red spectrum of the coating material but not present to any significant extent in the infra-red spectrum of the substrate.

There is also provided a method for fusing a powder coating on a substrate, in which fusing is carried out with infra-red radiation of wavelength in the range of from 3-6μm.

According to the sixth aspect of the invention, there is also provided an apparatus for fusing powder coating on a substrate, in which the apparatus is arranged to carry out the fusing with infra-red radiation, characterised in that the wavelength of the radiation used corresponds to a significant peak present in the infra-red spectrum of the coating material but not present to any significant extent in the infra-red spectrum of the substrate.

There is also provided an apparatus for fusing powder coating on a substrate, in which the apparatus is arranged to carry out the fusing with infra-red radiation of wavelength in the range of from 3-6μm

It will be understood that any features of the invention described in relation to one aspect of the invention may also be introduced into another aspect of the invention.

An embodiment of the invention will now be described with reference to the accompanying drawings of which

Figure 1	is a perspective view of a solid dosage form to be coated;
Figure 2	is a schematic plan view of the coating apparatus;
Figure 3	is a sectional view of the loading region of the apparatus of Figure 2;
Figure 4	is a schematic elevation view of the loading region;
Figure 5	is a sectional view of the developing region of the apparatus of Figure 2;
Figure 6	is a schematic elevation view of the developing region;
Figure 7	is a schematic elevation view of the fusing region of the apparatus of Figure 2;
Figure 8	is a schematic elevation view of the unloading region of the apparatus of Figure 2;
Figure 9	is a sectional view of the transfer region of the apparatus of Figure 2; and
Figure 10	is a schematic elevation view of the transfer region.

Figure 1 is a perspective view of a solid dosage form 101 which is to be coated in the coating apparatus of the present invention. In this example, the solid dosage form is a pharmaceutical tablet with a circumferential surface 102 and two domed end surfaces 103. Of course, the solid dosage form could be any shape which is appropriate for its particular application.

Figure 2 is a schematic plan view of the coating apparatus. The coating apparatus is generally designated 201 and incorporates apparatus for electrostatically applying a powder material to substrates. Two layers of platens 202, 203 are fixed to the apparatus and are arranged to rotate around the apparatus in the direction shown by the arrows. (Note that, as Figure 2 is a plan view, only the upper layer of platens is shown.)

The general operation of the apparatus is as follows. Solid dosage forms 101 are loaded into an upper platen 202 in the loading region, generally designated 205.

The upper platen 202 passes adjacent an upper developer in the developing region, generally designated 207. In this region, the first side of each solid dosage form is coated with powder material. The powder material on the first side of each solid dosage form is then fused as the upper platen passes through the fusing region, generally designated 209. The upper platen passes unaffected through the unloading region, generally designated 211. The solid dosage forms are then transferred to a lower platen 203 in the transfer region, generally designated 213. The lower platen 203 passes unaffected through the loading region 205 (whilst the now empty upper platen 202 is being reloaded with uncoated solid dosage forms). The lower platen 203 passes adjacent a lower developer in the developing region 207 (whilst the upper platen 202 passes adjacent upper developer). In this region, the second side of each solid dosage form is coated with powder material. The powder material on the second side of each solid dosage form is then fused as the lower platen passes through fusing region 209 (whilst the upper platen 202 also passes through fusing region 209). The now fully coated and fused solid dosage forms are unloaded from the lower platen in the unloading region 211. In the transfer region 213, the half coated and fused solid dosage forms in the upper platen 202 are transferred to the now empty lower platen 203. The upper platen is then ready to receive new uncoated solid dosage forms in the loading region 205.

Thus, uncoated solid dosage forms enter the apparatus 201 at loading region 205. Fully coated and fused solid dosage forms exit the apparatus at unloading region 211. Each solid dosage form passes through approximately one and three quarter circuits of the apparatus between entry and exit.

Each lower platen is associated with an upper platen to which it is fixed and each pair of platens (along with associated mountings and so forth as described below) is termed a carriage. Although the two platens are free to rotate and to move relative to each other in the vertical direction, they are fixed in the horizontal direction so move around the apparatus together. Thus, operations are

being carried out on the solid dosage forms in both platens simultaneously. For example, as each carriage passes through the fusing region, the coating on the solid dosage forms in the upper platen is being fused and the coating on the solid dosage forms in the lower platen is being fused simultaneously.

There is a single drive path for rotation around the apparatus, to which all the carriages are fixed. The carriages are independently driveable, however, so carriages may move at different speeds at different points on the drive path. Thus, the distance between carriages is not fixed. In the coating apparatus of Figure 2, the carriages move at a first constant speed through the developing region 207, fusing region 209 and unloading region 211. When moving through the transfer region 213 and loading region 205, the carriage has three temporary stops; the remainder of the time through the transfer region and the loading region, the carriage moves at a second constant speed, which is greater than the first constant speed. The movement of the carriage through the coating apparatus will be described more fully below.

Each region of the apparatus will now be described in more detail: the loading region is more fully described with reference to Figures 3 and 4, the developing region is more fully described with reference to Figures 5 and 6, the fusing region is more fully described with reference to Figure 7, the unloading region is more fully described with reference to Figure 8 and the transfer region is more fully described with reference to Figures 9 and 10.

Figure 3 is a sectional view of the loading region 205 and Figure 4 is a schematic elevation view of the loading region 205. Referring to Figures 3 and 4, upper platen 202 is fixed to an upper mounting 301 and lower platen 203 is fixed to a lower mounting 303. Upper 301 and lower 303 mountings are connected to a vertical bracket 305 which is connected to a drive system 307 which drives the pair of platens around the apparatus. As previously mentioned, each pair of

platens, with associated mountings, bracket and drive system is termed a carriage.

Each carriage is attached to a vacuum supply, not shown in Figures 3 and 4. The vacuum supply is connected to each mounting 301, 303 such that, when the vacuum supply is switched on, the resulting pressure difference acts to attract the solid dosage forms towards the platens. Thus, when the vacuum supply is operating, the platens may be inverted, and the solid dosage forms will remain positioned on the platen. The vacuum supply to each platen is independently operable.

Figure 3 shows the first section of the loading region, in which solid dosage forms 101 are supplied from a hopper 309 and are fed onto the upper platen 202 via first feeder 311. The operation in the first section of the loading region is as follows. The carriage moves into the first section of the loading region and, at a preselected position, there is a temporary carriage stop. While the carriage is stationary, the upper platen 202 moves vertically upward a short distance so that it is directly underneath the first feeder 311. First feeder 311 supplies sufficient solid dosage forms to fill the upper platen 202. The upper platen then moves vertically downward to its original vertical position. The carriage begins to move again. At this time, the upper platen 202 is gently vibrated to ensure that all the solid dosage forms are correctly positioned in the platen.

Referring to Figure 4, it will be seen that the loading region also comprises a second section, in which the platens are checked and the upper platen reloaded if required via second feeder 401. The operation in the second section of the loading region is as follows. As the carriage moves into the second section of the loading region, the upper platen 202 is inspected by solid dosage form inspector 403. Simultaneously, the vacuum supply to the lower platen 203 is switched on and the lower platen is then inverted. The vacuum supply ensures that the half coated solid dosage forms remain on lower platen 203 when it is in its inverted

orientation. At a preselected position, there is a temporary carriage stop. While the carriage is stationary, the upper platen moves vertically upward a short distance so that it is directly underneath second feeder 401. Second feeder supplies sufficient solid dosage forms to fill any gaps in the upper platen, which have been detected by the solid dosage form inspector 403. The upper platen then moves vertically downward to its original vertical position. The carriage begins to move again. At this time, the upper platen 202 is gently vibrated to ensure that all the solid dosage forms are correctly positioned in the platen. The vacuum supply to the upper platen is then switched on. As the carriage leaves the loading region 209, both platens are inspected once again by solid dosage form inspectors 405 and 407. Solid dosage form inspector 405 is above the upper platen. Solid dosage form inspector 407 is below the lower platen, as the lower platen is in its inverted orientation. Operation of the solid dosage form inspectors 403, 405 and 407 is described in more detail below.

From loading region 205, the carriages move towards the developing region. In the region between the loading region and the developing region, the platens may be manually or automatically checked again to ensure the solid dosage forms are correctly positioned. In addition, if necessary, any damaged or faulty platens may be removed and replaced here.

Figure 5 is a sectional view of the developing region 207 and Figure 6 is a schematic elevation view of the developing region 207.

The coating of the solid dosage forms is achieved electrostatically and it is advantageous that the powder material supply be beneath each solid dosage form 101 so that the powder material has to move upwards towards the solid dosage form 101. Thus, the platens are in their inverted orientation (and the vacuum supply is operating) as they pass over the powder material supply.

The operation in the developing region is as follows. On entry to the developing region, the upper platen 202 is in it upright orientation, whereas the lower platen 203 is in its inverted orientation. (It will be remembered that the lower platen was inverted in the second section of the loading region 205.) As the carriage moves into the developing region 207, the upper platen 202 is inverted. Thus, at this point, both platens 202, 203 are in their inverted orientation, ready to pass over a powder material supply. Under normal operation, the upper platen contains a set of uncoated solid dosage forms and the lower platen contains a set of half coated and fused solid dosage forms with the uncoated sides now exposed for coating,

As the upper platen 202 is being inverted, the lower platen 203 passes over the developer units 501 and powder material is attracted from each developer unit 501 onto the exposed surface of the solid dosage forms in the lower platen 203. As the carriage moves on, the lower platen is inspected by solid dosage form inspector 503. The upper platen passes over developer units 505 and powder material is attracted from each developer unit 505 onto the exposed surface of the solid dosage forms in the upper platen 202. The upper platen is then inspected by solid dosage form inspector 507. Operation of the solid dosage form inspectors 503 and 507 is described in more detail below.

On the coating apparatus shown, there are two identical individual developer units at each level and each platen passes smoothly over each developer unit in succession. There may, of course, be a different number of developer units and this will depend on the particular application.

As previously mentioned, it is important with electrostatic application of powder material that the distance between the powder supply and the surface to be coated is accurately controllable as the distance between the powder material supply must be small enough to allow the powder material to "jump" onto the surface of the solid dosage form but not so small that the surface gets over coated with powder material. Typically, this distance is of the order of 1 cm. In

order to achieve accuracy, the platens 202, 203 are fixed to the mountings 301, 303 but they are allowed to move relative to the mounting by a small distance in the vertical direction. At the developer unit, the drive path includes a guide (not shown) which may be a part of the developer unit and which fixes each platen at a selected vertical position for the duration of the coating process. That vertical position may be selected according to the actual required powder supply to surface distance for a given application. Thus, although the platens are substantially fixed in the vertical direction, this small freedom of movement ensures that accuracy can be achieved during the coating process. It also means that the actual powder supply surface distance is easily adjustable simply by adjustment of the guide.

Each developer unit is an independent unit which contains a supply of powder material. Each unit is designed so that portions of the unit which are "clean" (i.e. do not come into contact with powder material) are separate from portions of the unit which are "dirty" (i.e. do come into contact with the powder material and will therefore need regular cleaning). The "clean" portions are integral with the unit itself, whereas the "dirty" portions are located in a separate cartridge which is easily replaceable by the user.

From the developing region 207, the carriages move towards the fusing region. In the region between the developing region and the fusing region, both platens are rotated, in turn, back to their upright orientation, so that they are ready to pass through fusing region 209.

Figure 7 is a schematic elevation view of part of fusing region 209. The fusing region comprises two fusing tunnels, an upper fusing tunnel 701 and a lower fusing tunnel 703. Each fusing tunnel comprises a heat source (typically a ceramic element, not shown) positioned on the inside upper surface of the fusing tunnel. It can be seen from Figure 2 that the fusing region 209 occupies one entire side of the coating apparatus 201. As upper platen 202 passes along

upper fusing tunnel 701, the powder material on the first side of the solid dosage forms in the upper platen is fused. As lower platen passes along lower fusing tunnel 703, the powder material on the second side of the solid dosage forms in the lower platen is fused. Thus, under normal operation, once the carriage has moved through entire fusing region 209, the solid dosage forms on upper platen 202 are coated and fused on one side and are ready to be coated and fused on the second side and the solid dosage forms on lower platen 203 are coated and fused on both sides and are ready to exit the apparatus.

The amount of the time and the temperature required for fusing will depend on the particular solid dosage form and powder material. Therefore, the platens may be raised or lowered in the fusing tunnels to alter the distance between the solid dosage forms and the heat source. Also, the temperature of the heat source may be changed. Also, the fusing tunnels may not extend for the full length of one side of the coating apparatus or part of the fusing tunnels may not include a heat source. Various other changes may be made to the fusing region 209 to take account of different solid dosage forms and powder materials. In general, it has been found that the dimensions of the entire coating apparatus are often dependent on the size of the fusing region which is required for a given application.

It will be noted that, throughout the fusing region, the vacuum supply is operating for both upper and lower platens even though neither platen is in its inverted orientation. (It will be remembered that the vacuum supply for the upper platen was switched on as the carriage left the second section of the loading region and the vacuum supply for the lower platen was switched on as the carriage entered the second section of the loading region.) This is because it has been found that for some solid dosage forms, as the solid dosage form is heated in order to fuse the powder material, bubbles of gas are formed in the solid dosage form and those bubbles rise to the surface of the solid dosage form, and bubble through the partially fused powder material, causing an uneven surface effect on the

resulting coated solid dosage form. In order to solve this problem, the vacuum supply is operating for both the lower and upper platen as the carriage moves through the fusing region. Then, as bubbles of gas form in the solid dosage form, they move towards the platen rather than towards the powder material which is being fused, thereby avoiding any bubbling of the powder material being fused and ensuring a smooth surface coating for the solid dosage form.

From fusing region 209, the carriages move towards the unloading region. In the region between the fusing region and the unloading region, the lower platen is inverted. As the vacuum supply for the lower platen is still operating, the solid dosage forms remain on the lower platen.

Figure 8 is a schematic elevation view of the unloading region 211. The operation in the unloading region is as follows. As the carriage enters the unloading region, the upper platen 202 is inverted. As the vacuum supply to the upper platen is still operating, the solid dosage forms remain positioned on the upper platen. Under normal operation, the upper platen passes through the unloading region 211 without undergoing any further process steps. As the lower platen 203 (which is already in its inverted orientation) enters the unloading region, it passes over a lower conveyor 801. The vacuum supply for the lower platen 203 is then switched off and, as a result, the fully coated and fused solid dosage forms fall onto the lower conveyor 801. The lower platen is then gently vibrated to ensure that no solid dosage forms remain fixed to the lower platen. The lower platen is then brushed and vacuum cleaned by cleaner 803 and is then inspected by solid dosage form inspector 805. The lower platen should, at this point, be empty of solid dosage forms and be free from any excess powder material or dirt. Operation of the solid dosage form inspector 805 will be described in more detail below. From unloading region 211, the carriages move towards the transfer region. In the region between the unloading region and the transfer region, the empty lower platen is rotated again to return to its upright orientation.

As mentioned above, under normal operation, after the upper platen 202 is inverted, it passes through the unloading region 211 without undergoing any further process steps. However, the apparatus is adaptable so that, if it is necessary to unload solid dosage forms from the upper platen in this region (for example if the solid dosage forms are to be coated on one side only), this can be done in unloading region 211. In that case, as before, as the carriage enters the unloading region, the upper platen 202 is inverted. The upper platen then passes over an upper conveyor 807. The vacuum supply for the upper platen 202 is then switched off and, as a result, the solid dosage forms fall onto the upper conveyor 807. The upper platen is then gently vibrated to ensure that no solid dosage forms remain fixed to the upper platen.

The solid dosage forms which fall onto the upper or lower conveyor pass along the conveyor before falling into kegs. The solid dosage forms are checked (either manually or automatically), faulty solid dosage forms being directed into reject kegs and correct solid dosage forms being directed into product kegs.

Figure 9 is a sectional view of the transfer region 213 and Figure 10 is a schematic elevation view of the transfer region 213. Referring to Figure 10, operation in the transfer region is as follows. The carriage moves into the transfer region and, at a preselected position, there is a temporary carriage stop. It will be remembered that, at this point, upper platen 202 is in its inverted orientation and lower platen 203 is in its upright orientation. While the carriage is stationary, the lower platen 203 moves vertically upward until it is in contact with or very close to upper platen 202. The vacuum supply for the upper platen 202 is then switched off and, as a result, the solid dosage forms fall the short distance onto the lower platen 203, so that their uncoated sides are now exposed. The upper platen is gently vibrated to ensure that no solid dosage forms remain fixed to the upper platen. The lower platen 203 then moves vertically downward to its original vertical position. The carriage begins to move again. At this time, the lower platen 203 is gently vibrated to ensure that all the solid dosage forms are correctly

positioned in the platen. The upper platen 202 is brushed and vacuum cleaned by cleaner 901 and is then inspected by solid dosage form inspector 903. The upper platen should, at this point, be empty of solid dosage forms and be free from any excess powder material or dirt. The solid dosage form inspector 903 will be described in more detail below.

As described above with reference to Figure 8, it is possible for the upper platen 202 to be unloaded in unloading region 211. In that case, the upper platen 202 will enter the transfer region 213 empty and there will be no need to transfer solid dosage forms to lower platen 203. The upper platen can simply be brushed and vacuum cleaned by cleaner 901 and inspected by solid dosage form inspector 903.

As the carriage leaves the transfer region, the upper platen is rotated to return to its upright orientation.

From transfer region 213, the carriages move immediately into loading region 205 where the upper platen is fed with solid dosage forms once again by first tablet feeder 311.

From the description, it will be seen that there are three temporary carriage stops for each carriage in the transfer and loading regions, one in the transfer region and two in the loading region. Therefore, when the carriage is moving through these regions (rather than stationary), it moves at a higher speed than the speed at which it moved through the remaining regions of the coating apparatus, in order to compensate for the temporary carriage stops.

Operation of the solid dosage form inspectors 403, 405, 407, 503, 507, 805 and 903 is now described more fully. Inspectors in this sort of arrangement are well known and usually take the form of a camera or cameras positioned alongside each platen. If the platen should be full of solid dosage forms, the inspector can

be arranged so that any missing solid dosage form results in a signal, which can, for example, trigger a subsequent feeder (e.g. second feeder 401 in Figure 4) to provide a solid dosage form to the relevant position in the platen. Alternatively, if the platen should be empty, the inspector can be arranged so that any solid dosage form unintentionally on the platen results in a signal, which can, for example trigger a cleaner to clean the relevant position or provide an instruction to a user to replace the particular platen with a clean one.

The solid dosage form inspectors 403, 405, 407, 503, 507, 805 and 903 in the coating apparatus illustrated preferably use fibre-optic sensors rather than cameras. The fibre optic sensors are arranged to sense a variety of colours, which is useful if the coating apparatus is to be used with a variety of coatings and substrates. The sensors are operable remotely.

Referring once again to Figure 2, it will be seen that there are two vertical walls between the product region (i.e. the loading, developing, fusing, unloading and transfer regions) and the non product regions (i.e. the drive systems for the carriages and the other mechanics of the coating apparatus). The outer wall 215 divides the product region 219 from an annular chamber 221. The inner wall 217 divides the annular chamber 221 from the non-product region 223. The platens are located on the outside of the outer wall 215, the platen mountings pass through the outer and inner walls and the vertical bracket and drive system are located on the inside of the inner wall 217. The mountings pass through horizontal channels (not shown) in the inner and outer walls which are sealable (e.g. by flexible lips). The horizontal channels allow the carriage to move around the circuit and the flexible lips prevent excess powder material or pollutants moving between the product region and the annular chamber. At appropriate points on the circuit, vertical channels (not shown), which are also sealable e.g. by flexible lips, are provided in order to allow the platens to move in the vertical direction.

The advantage of this arrangement is that the product and non product regions are entirely separate. This reduces the possibility that the solid dosage forms are contaminated (which is of particular importance in a pharmaceutical context). It also reduces the likelihood that the non-product regions will become excessively dirty from excess powder material and this will reduce cleaning and replacement costs. To further prevent any material passing between the product and non-product regions, the annular chamber includes an airflow in the vertical direction. Therefore, if any material does inadvertently pass through the outer wall or the inner wall into the annular chamber, it will immediately be carried out of the chamber in the vertical air flow. Access to the non-product region for engineers may be via a sealable crawl track under the apparatus or via a vertical ladder from above.

In one embodiment, the dimensions of the coating apparatus are as follows. The track length of the coating apparatus is 12 600 mm (measured at the inner edge of the platens). The straight length of the coating apparatus is 4700 mm and the straight width of the coating apparatus is 1600 mm. The apparatus includes 28 carriages (i.e. 56 platens). The carriages move through the developing region, fusing region and unloading region at a constant speed of 50 mm/s. The carriages move through the transfer region and the loading region at a speed of 200 mm/s with three temporary carriage stops. Thus, each circuit of the apparatus takes each carriage 252 s. Thus, when working under normal operation, the coating apparatus can produce 400 platens of fully coated and fused solid dosage forms per hour. Typically, each platen will contain about 450 solid dosage forms. Thus, the coating apparatus can produce about 180,000 solid dosage forms per hour.

Claims:

1. An apparatus for electrostatically applying a powder material to substrates, the apparatus comprising:

a plurality of platens fixed to move along an endless path, each platen being arranged to hold a plurality of substrates;

driving means for driving the platens along the endless path; and

an applicator assembly for applying the powder material to the substrates, the applicator assembly being located on a part of the endless path.

2. An apparatus according to claim 1 wherein the applicator assembly comprises at least one applicator having a supply of powder material and charging means for electrostatically charging the powder material.

3. An apparatus according to claim 2 wherein a portion of the applicator is replaceable by a user, the replaceable portion including the supply of powder material.

4. An apparatus according to any one of the preceding claims further including a fusing assembly for fusing powder material electrostatically applied to the substrates, the fusing assembly being located on a part of the endless path.

5. An apparatus according to claim 4 wherein the fusing assembly comprises a plurality of fusing devices disposed in series along the endless path.

6. An apparatus according to any one of the preceding claims further including a loading station for loading substrates onto the platens.

7. An apparatus according to any one of the preceding claims further including an unloading station for removing substrates from the platens.

8. An apparatus according to any one of the preceding claims further including a transfer station for transferring the substrates between platens.

9. An apparatus according to any one of the preceding claims further including at least one detector for inspecting the platens.

10. An apparatus according to claim 9 wherein the at least one detector comprises a plurality of optic fibres.

11. An apparatus according to claim 9 or claim 10 wherein the at least one detector is arranged to detect a variety of colours.

12. An apparatus according to any one of claims 9 to 11 wherein the detector is remotely operable.

13. An apparatus according to any one of the preceding claims wherein the driving means is arranged to drive the platens along the endless path at a plurality of speeds.

14. An apparatus according to any one of the preceding claims wherein the endless path is substantially horizontal.

15. An apparatus according to claim 14 further including a vertical partition separating the driving means from the platens, the driving means being located in a non-product region and the platens being located in a product region.

16. An apparatus according to claim 15 further including a second vertical partition separating the non-product region from the product region, the first and second vertical partitions defining a substantially annular chamber between the non-product region and the product region.

17. An apparatus according to claim 16 wherein the substantially annular chamber includes an air flow in the vertical direction.

18. An apparatus according to any one of claims 14 to 17 wherein the platens are fixed to move along the endless path in pairs, one of the platens in the pair being located above the other platen in the pair.

19. An apparatus according to claim 18 wherein the platens in each pair are movable with respect to one another in the vertical direction.

20. An apparatus according to claim 18 or claim 19 wherein the applicator assembly for applying the powder material to the substrates comprises at least one upper applicator for applying the powder material to substrates in the upper platen and at least one lower applicator for applying the powder material to substrates in the lower platen.

21. An apparatus according to claim 20 wherein the upper and lower applicators are arranged to supply powder material to the substrates substantially simultaneously.

22. An apparatus according to claim 20 wherein the upper and lower applicators are arranged to supply powder material to the substrates sequentially.

23. An apparatus according to any one of claims 18 to 22 further including a fusing assembly comprising an upper fuser for fusing powder material electrostatically applied to the substrates in the lower platen and a lower fuser for fusing powder material electrostatically applied to the substrates in the upper platen.

24. An apparatus according to claim 23 wherein the upper and lower fusers are arranged to fuse powder material on the substrates substantially simultaneously.

25. An apparatus according to any one of claims 18 to 24 further including a transfer station for transferring substrates from the upper platen to the lower platen.

26. An apparatus according to claim 25 wherein the transfer station is arranged to move the platens relative to one another in the vertical direction such that a face of the lower platen is adjacent a face of the upper platen, the face of the upper platen holding a plurality of substrates, to shift the plurality of substrates from the face of the upper platen to the adjacent face of the lower platen and to separate the adjacent faces of the upper and lower platens.

27. An apparatus according to claim 25 or claim 26 wherein the transfer station includes at least one vibrator for vibrating one or both platens.

28. A method for electrostatically applying a powder material to substrates, the method comprising the steps of:

providing a plurality of platens fixed to move along an endless path, each platen being arranged to hold a plurality of substrates;

placing the substrates on the platens;

driving the platens in series along an endless path; and

electrostatically applying a powder material to the substrates on the platens.

29. A method according to claim 28 wherein the step of electrostatically applying a powder material comprises driving the platens past at least one applicator having a supply of powder and charging means for electrostatically charging the powder material.

30. A method according to claim 28 or claim 29 further comprising the step of fusing the powder material after it is electrostatically applied.

31. A method according to claim 30 wherein the step of fusing comprises driving the platens past a plurality of fusing devices disposed in series along the endless path.

32. A method according to any one of claims 28 to 31 further comprising the step of removing the substrates from the platens after the powder material has been electrostatically applied.

33. A method according to any one of claims 28 to 32 further comprising the step of transferring the substrates between platens.

34. A method according to claim 33 wherein the step of transferring the substrates between platens comprises vibrating one or both platens.

35. A method according to any one of claims 28 to 34 further comprising the step of inspecting the substrates in the platens.

36. A method according to any one of claims 28 to 35 wherein the step of driving the platens along the endless path comprises driving the platens simultaneously at a plurality of speeds.

37. A method according to any one of claims 28 to 36 wherein the endless path along which the platens are driven is substantially horizontal.

38. A method according to any one of claims 28 to 37 wherein the substrates are pharmaceutical substrates.

39. A method according to any one of claims 28 to 39 wherein the substrates are solid dosage forms.

40. A method according to any one of claims 28 to 39 wherein the substrates are cores of pharmaceutical tablets.

41. An apparatus according to any one of claims 1 to 27 for carrying out the method of any one of claims 28 to 40.

42. An apparatus substantially as hereinbefore described and as illustrated by the accompanying drawings.

43. A method of electrostatically applying a powder material to opposite faces of each of a plurality of substrates, the method comprising the steps of:

providing an upper platen and a lower platen, the upper platen being located vertically above the lower platen, each platen being arranged to hold a plurality of substrates;

providing a plurality of substrates on the upper face of the upper platen;

electrostatically applying powder material to exposed first faces of each of the plurality of substrates on the upper platen;

rotating the upper platen so that the plurality of substrates is located on the lower face of the upper platen;

moving the platens relative to one another in the vertical direction such that the upper face of the lower platen is adjacent the lower face of the upper platen;

shifting the plurality of substrates from the lower face of the upper platen to the upper face of the lower platen;

separating the adjacent faces of the upper and lower platens; and

electrostatically applying powder material to exposed second faces of each of the plurality of substrates on the lower platen.

44. A method according to claim 43 wherein the step of shifting the plurality of substrates from the lower face of the upper platen to the upper face of the lower platen includes vibrating one or both platens.

45. An apparatus for electrostatically applying a powder material to substrates, the apparatus comprising:

a plurality of pairs of platens fixed for movement about an endless horizontal path, each pair of platens comprising a lower platen and an upper platen located vertically above the lower platen, each platen being arranged to hold a plurality of substrates;

an applicator assembly for applying the powder material to the substrates, the applicator assembly being located on a part of the endless path; and

a transfer station for moving the platens relative to one another in the vertical direction such that the upper face of the lower platen is adjacent the lower face of the upper platen, the lower face of the upper platen holding a plurality of substrates, for shifting the plurality of substrates from the lower face of the upper platen to the upper face of the lower platen and for separating the adjacent faces of the upper and lower platens.

46. An apparatus according to claim 45 wherein the transfer station comprises a vibrator for vibrating the upper and/or lower platens.

47. An apparatus according to claim 45 or claim 46 wherein the applicator assembly comprises at least one upper applicator for applying the powder material to substrates in the upper platen and at least one lower applicator for applying the powder material to substrates in the lower platen.

48. An apparatus for electrostatically applying a powder material to substrates, the apparatus comprising:

a plurality of platens fixed to move along an endless path, each platen being arranged to hold a plurality of substrates;

an applicator assembly located on a part of the endless path for applying the powder material to substrates; and

driving means for driving the platens along the endless path, the driving means being arranged to drive platens simultaneously at a variety of speeds.

49. A method for electrostatically applying a powder material to substrates, the method comprising the steps of:

providing a plurality of platens fixed to move along an endless path, each platen being arranged to hold a plurality of substrates;

placing the substrates on the platens;

driving the platens in series along an endless path, each platen being independently driveable at a variety of speeds; and

electrostatically applying the powder material to the substrates on the platens.

50. A carriage for conveying substrates along a path, the carriage comprising:

an upper platen for holding a plurality of substrates;

a lower platen for holding a plurality of substrates;

a bracket for supporting the upper and lower platen, the upper and lower platen being rotatably mounted on the bracket and being movable vertically with respect to one another; and

driving means for driving the carriage along the path.

51. A carriage according to claim 50 wherein, when the substrates are conveyed along the path by the carriage, the vertical separation of the upper platen and the lower platen is substantially preselected by a user, but the upper platen and/or the lower platen are free to move a small amount in the vertical direction.

52. An apparatus for electrostatically applying a powder material to substrates, the apparatus comprising:

a product region comprising a plurality of platens fixed to move along an endless path, each platen being arranged to hold a plurality of substrates and an applicator assembly located on a part of the endless path for applying the powder material to substrates;

a non-product region comprising driving means for driving the platens along the endless path; and

a partition separating the product region and the non-product region.

53. An apparatus according to claim 52 further comprising a second partition separating the product region and the non-product region, the two partitions defining an insulating chamber.

54. An apparatus according to claim 53 wherein the insulating chamber includes an air flow in a direction substantially parallel to the partitions.

55. An apparatus according to any one of claims 52 to 54 wherein the endless path is substantially horizontal and the partition or partitions is/are substantially vertical.

Figure 1

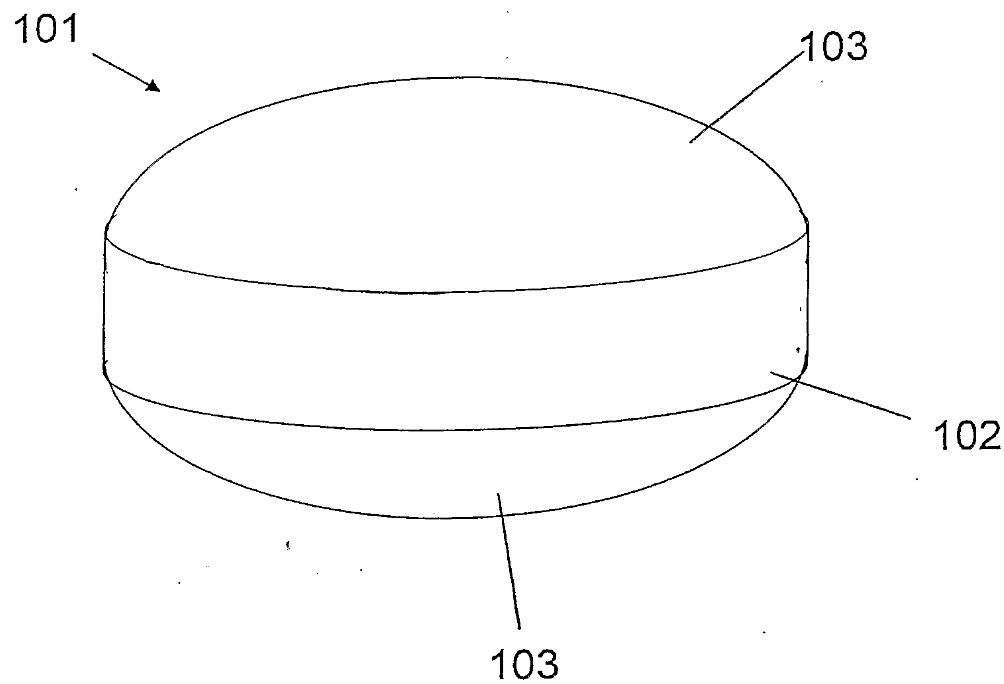
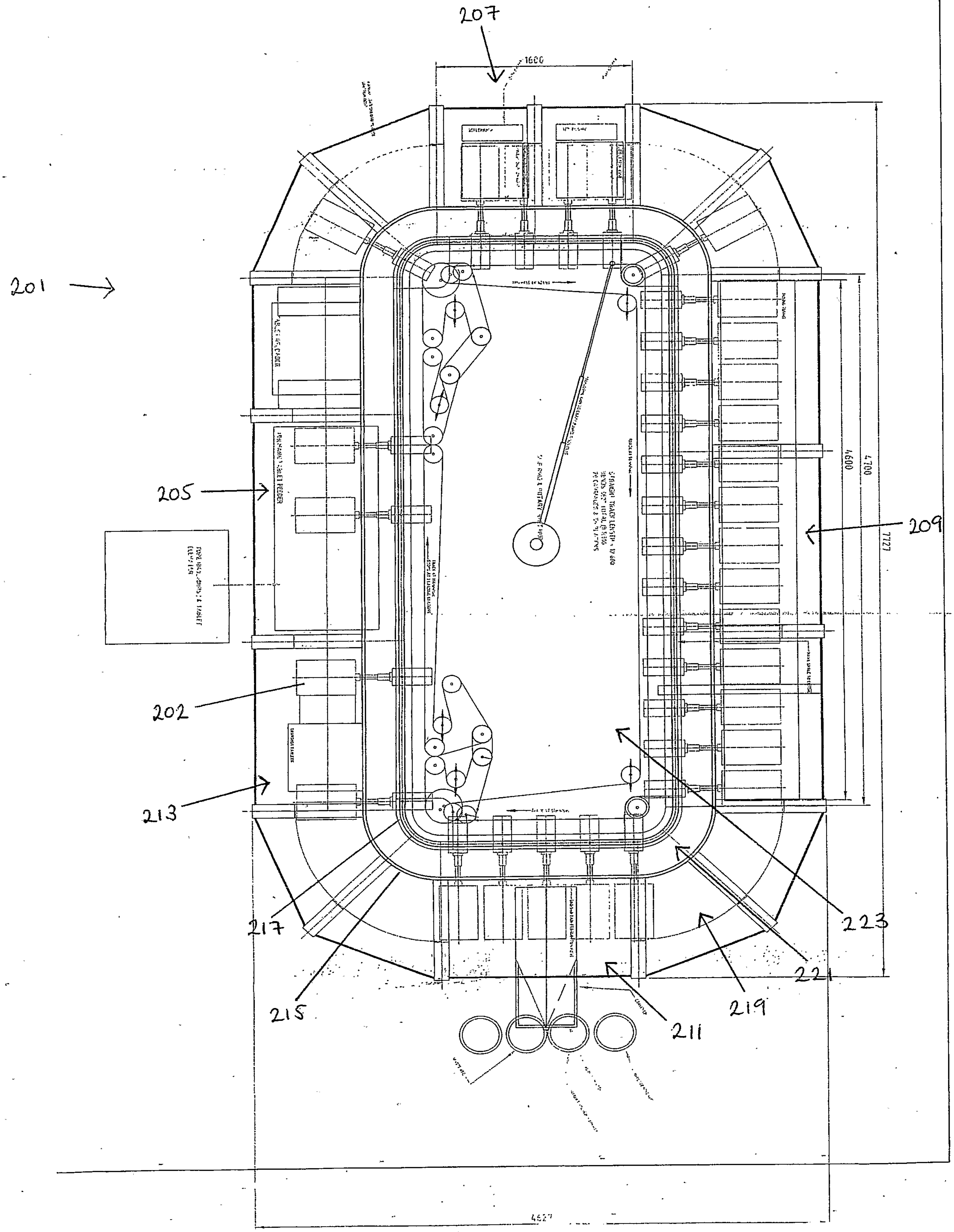


FIGURE 2


207
1600
201
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202
213
209
4600
4700
7727
223
217
215
211
219
221
4627

FIGURE 3

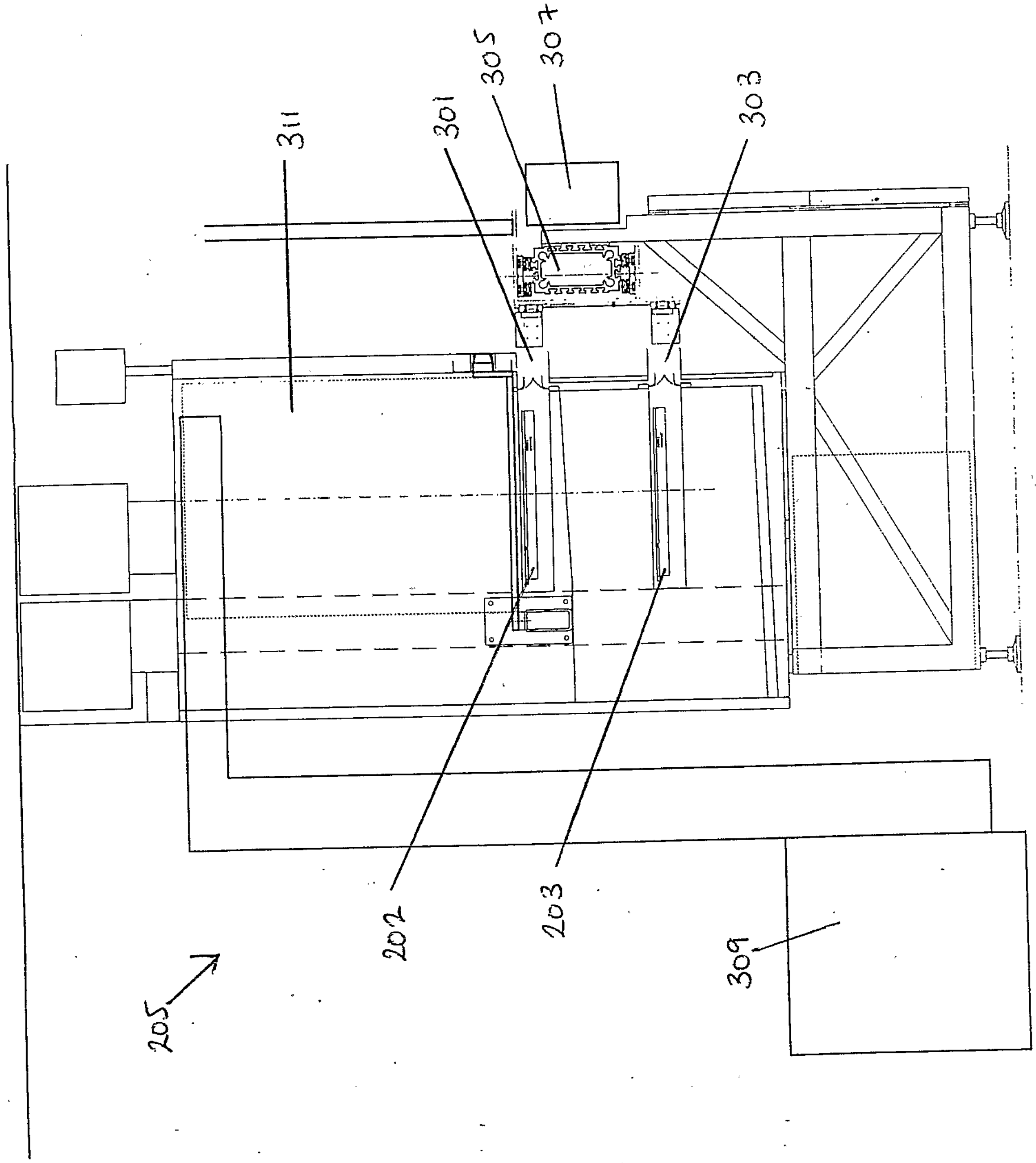


FIGURE 4

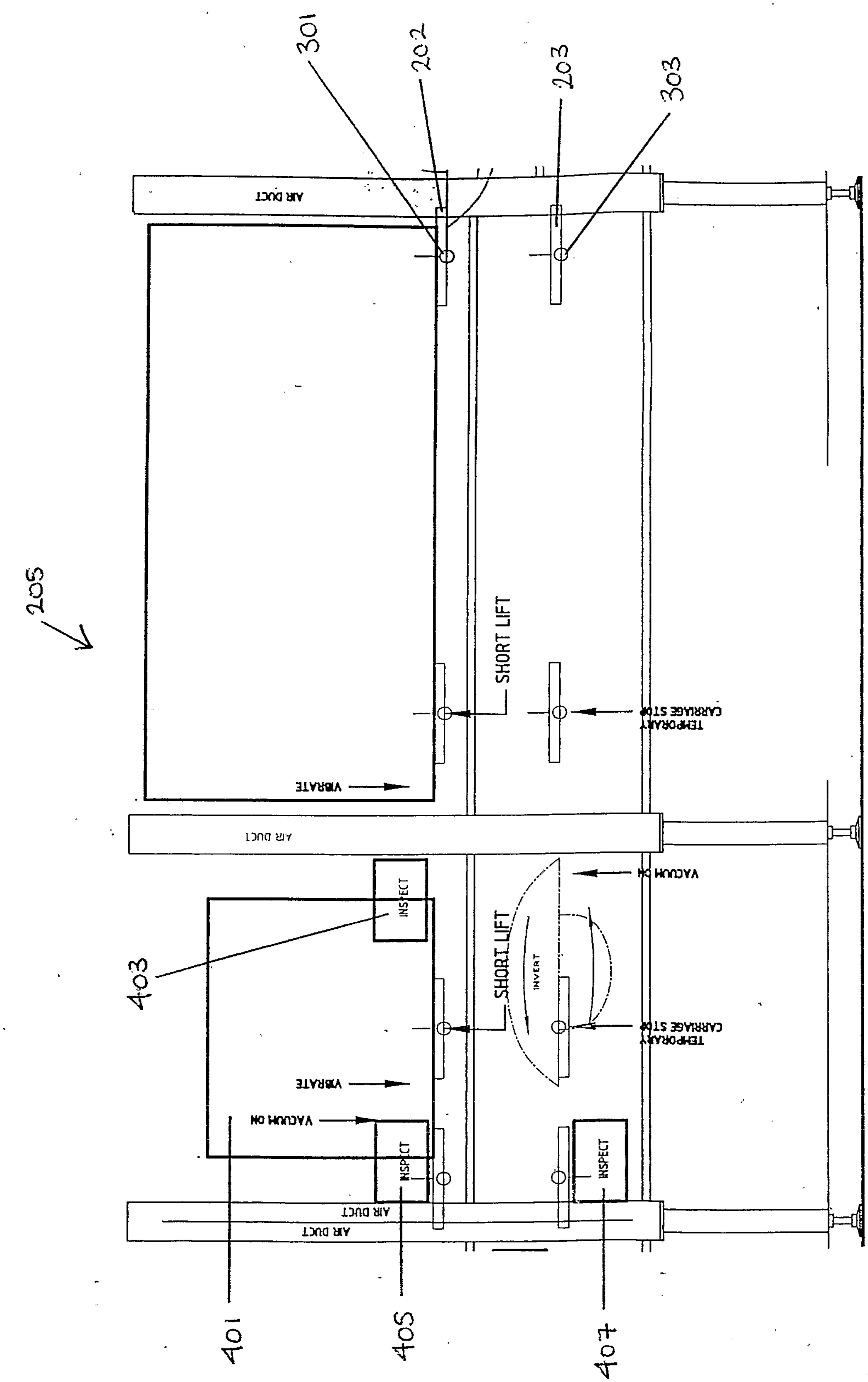

205
301
202
203
303
AIR DUCT
AIR DUCT
AIR DUCT
AIR DUCT
SHORT LIFT
SHORT LIFT
TEMPORARY CARRIAGE STOP
TEMPORARY CARRIAGE STOP
VIBRATE
VIBRATE
VACUUM ON
VACUUM ON
INSPECT
INSPECT
INSPECT
INVERT
403
401
405
407

FIGURE 5

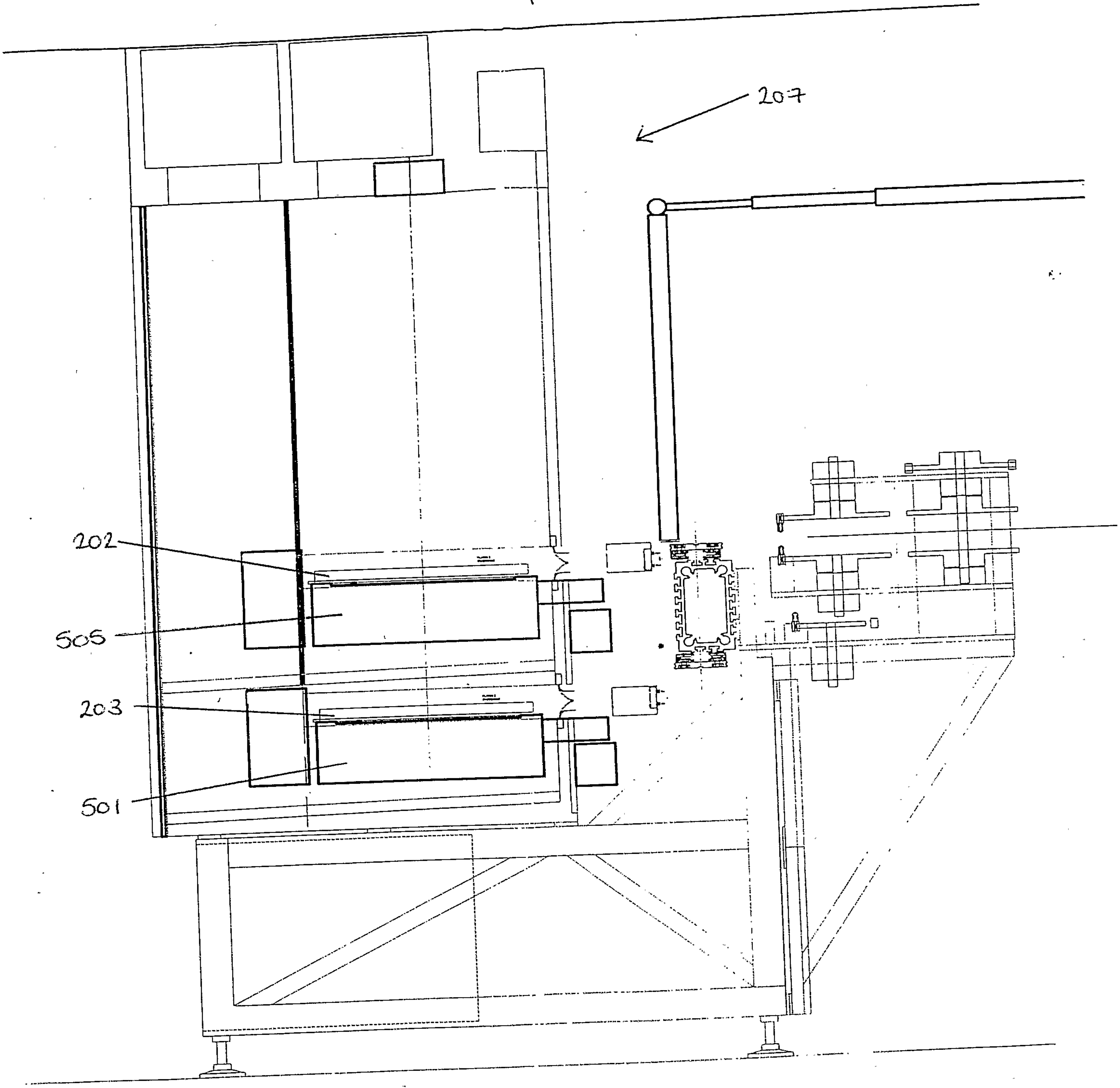


FIGURE 6

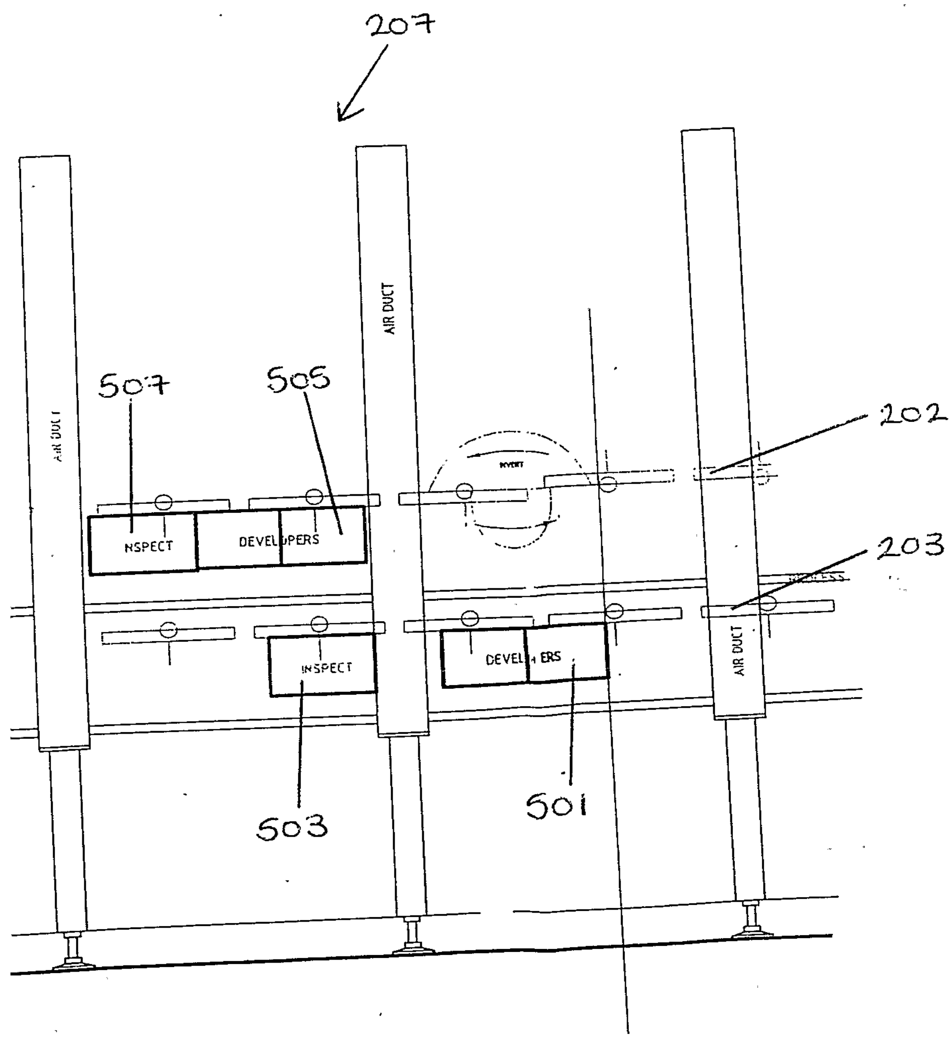

207
AIR DUCT
AIR DUCT
AIR DUCT
507
505
202
203
NSPECT
DEVELOPERS
INSPECT
DEVEL ERS
503
501

FIGURE 7

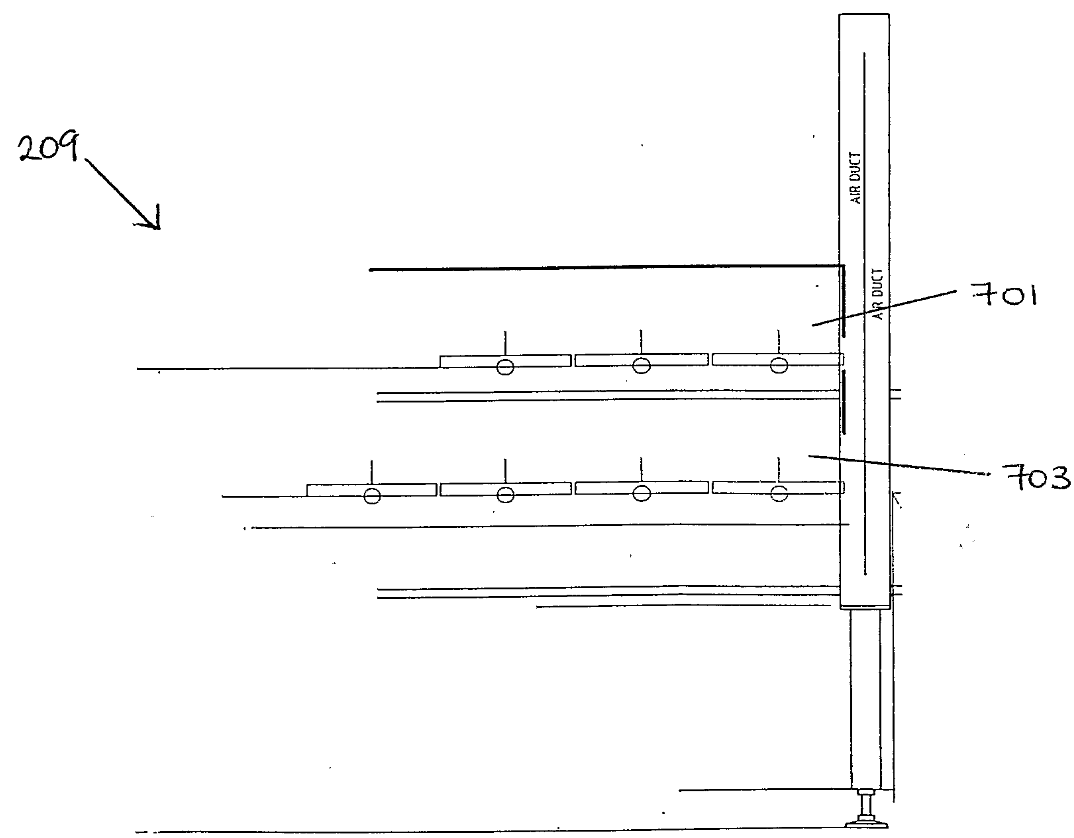
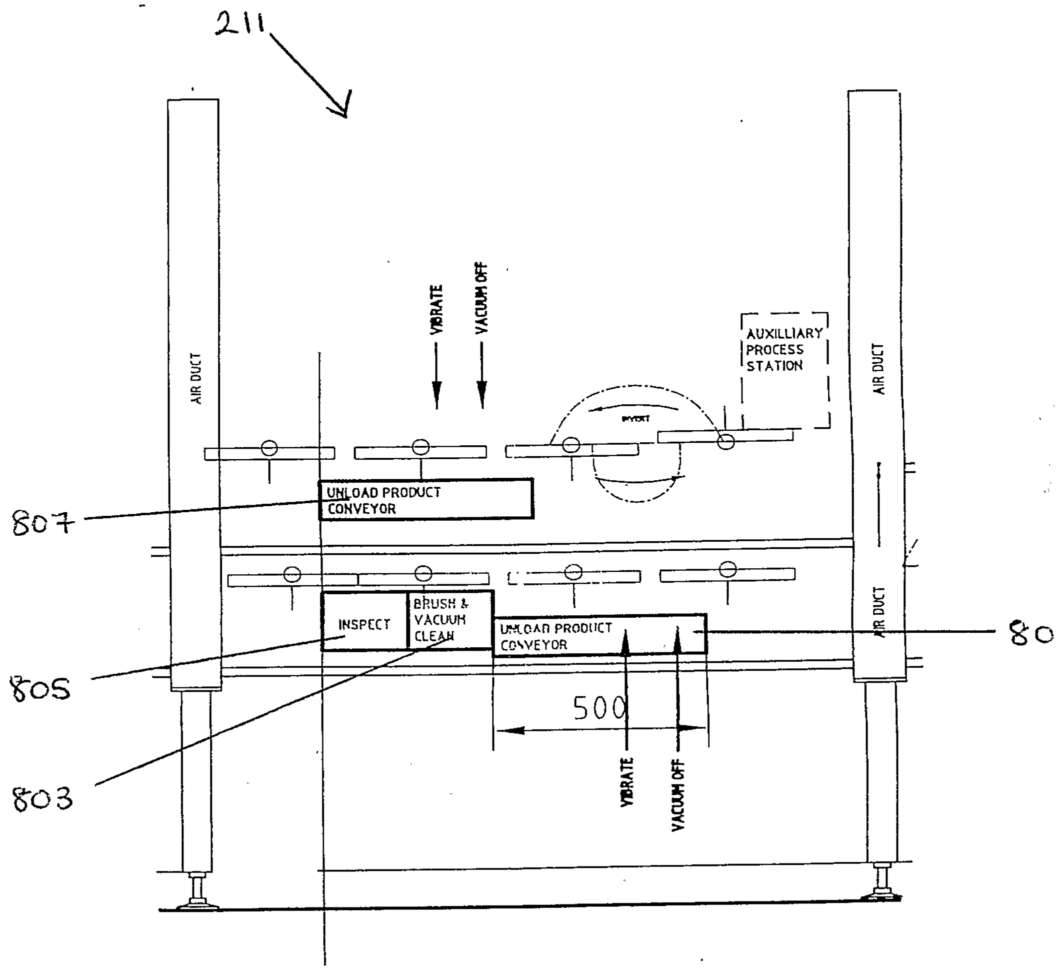


FIGURE 8



211
AIR DUCT
VIBRATE
VACUUM OFF
AUXILLIARY PROCESS STATION
AIR DUCT
INVERT
UNLOAD PRODUCT CONVEYOR
807
INSPECT
BRUSH & VACUUM CLEAN
UNLOAD PRODUCT CONVEYOR
AIR DUCT
801
805
500
803
VIBRATE
VACUUM OFF

FIGURE 9

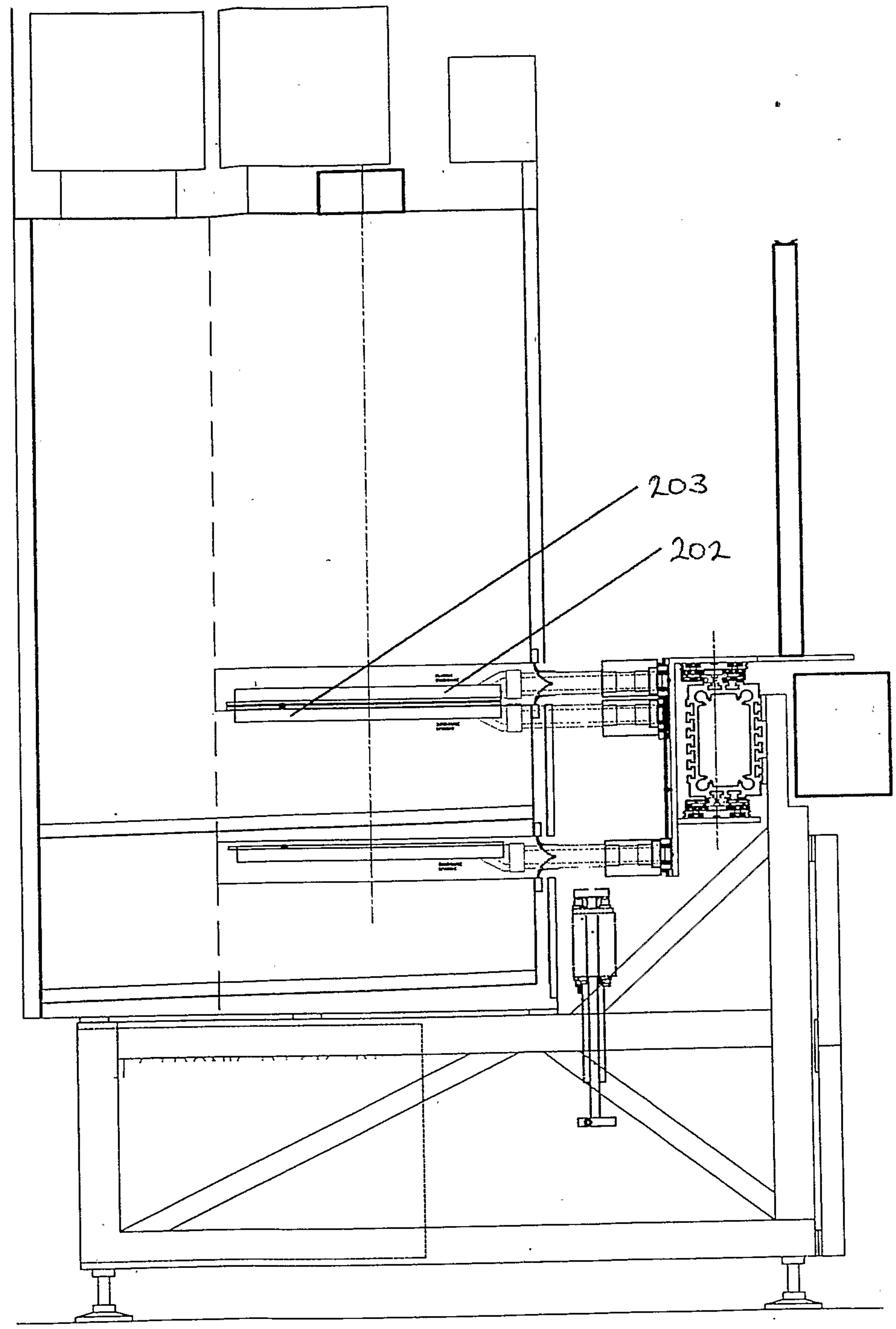
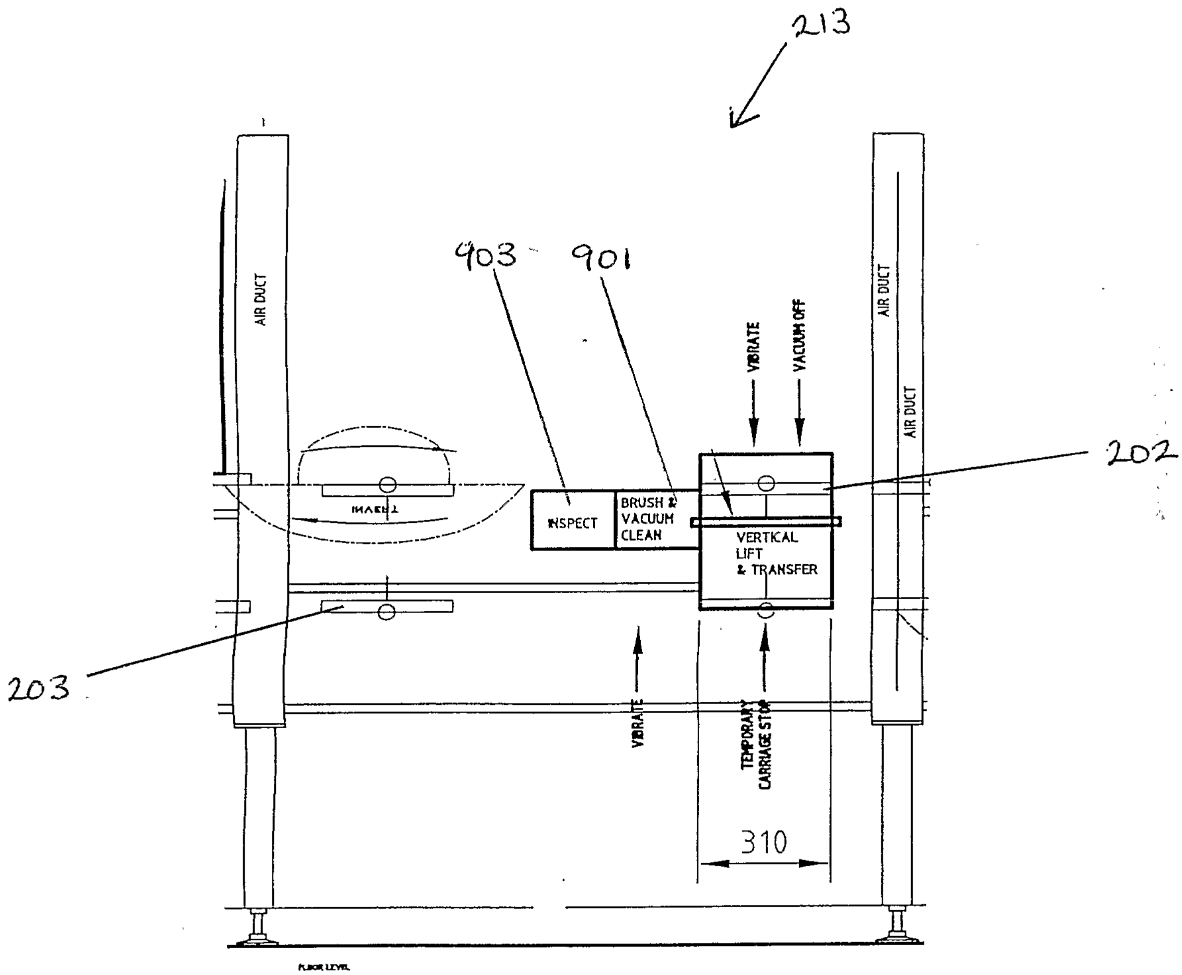


FIGURE 10


213
903
901
AIR DUCT
AIR DUCT
AIR DUCT
VIBRATE
VACUUM OFF
202
INSPECT
BRUSH & VACUUM CLEAN
VERTICAL LIFT & TRANSFER
203
VIBRATE
TEMPORARY CARRIAGE STOP
310